Towards strategic sustainability: the barriers and enablers of supplier involvement in product stewardship and clean technology strategies

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Abstract

Many of today's firms see sustainability as an exercise in cost and risk minimization. Using the Natural Resource Based View this paper calls for a more strategic approach to sustainability; one that involves suppliers in embedding product stewardship and clean technology strategies in new product development efforts. A case study of a high technology firm is used including forty-two interviews, eight focus groups and secondary data. Theoretically, the paper isolates the effects of technological uncertainty on supplier involvement in product stewardship and clean technology strategies. Practically, the paper advances a matrix for identifying appropriate levels of supplier involvement for each strategy.

Keywords: Supplier Involvement in Sustainable New Product Development, Strategic Sustainability

Introduction

External stakeholders are applying increasing pressure on firms to improve sustainability performance. These stakeholders make little distinction between a firm's internal operation and its supply chain. Much of the literature on "Green" and "Sustainable" Supply Chain Management examines how firms implement pollution prevention techniques to minimize costs and risks using short-term tactical as opposed to long-term strategic investment decisions (Hart, 1995). This view is supported by a variety of studies; Klassen and Whybark (1999) show how a greater emphasis on pollution prevention technologies improves cost, delivery, flexibility, and environmental performance. Christmann (2000) states the early use of pollution prevention technologies provides a cost advantage relative to competitors. Aragon-Correa and Sharma (2003) explain that proactive pollution prevention strategies enable an organization to align itself with changes in the business environment and lead to lower costs. Seuring and Muller's (2008) sustainable supply chain management framework considers supplier management for risks and performance while Carter and Rogers (2008) focus on organizational culture, transparency, and risk management. While no doubt informative, this body of literature tends to centre on how firms use sustainability as a short-term cost and risk reduction exercuse rather than a way to achieve long-term competitive advantage.

The Natural Resource Based View (NRBV) argues firms should move beyond pollution prevention towards a more strategic approach to sustainability using product stewardship and clean technology strategies (Hart, 1995; 1997). Product stewardship strategies incorporate the views of external stakeholders in product design and lifecycle analysis. Clean technologies are radical in nature with the potential to revolutionize entire industries (Hart, 1997; Hart and Dowell, 2011). Hart and Dowell (2011) reported a robust body of literature exploring pollution prevention but much less attention paid to how product stewardship and clean technology strategies could be employed to realise sustainable competitive advantage; this development was the key argument of NRBV.

Within the supply chain literature there is a growing body of work on supplier involvement in new product development (SINPD). Recently supplier involvement has been segregated into four levels of engagement including: no involvement, "white box" involvement where the supplier consults informally on design, "grey box" involvement where suppliers collaborate on design and development and finally "black box" involvement where the supplier is responsible for the design and development of entire components or subassemblies (Petersen et al., 2003; 2005; Koufteros et al., 2007). Although this literature stresses the importance of supplier involvement it concentrates on economic benefits paying limited attention to the natural environment or society.

To address the gap in the NRBV and SINPD literature this paper poses the following research question: "*how can suppliers help firms embed product stewardship and clean technology strategies in the new product development cycle*?" We use an in-depth case study of a high technology aerospace firm and include a supplier and customer, termed a triadic case study design. This format allows the researcher to isolate which actor is helping or hindering the embedding of each strategy in the NPD cycle.

The paper is divided into five sections. The first section reviews the literature surrounding the NRBV and SINPD to highlight the significance of technological uncertainty. Section two provides an overview of the research method. Section three presents the research findings while section four provides a discussion and advances a decision matrix for selecting the appropriate degree of supplier involvement in each strategy. Finally we discuss the theoretical and managerial implications of the study, the paper's limitations and future avenues of research.

Literature Review

The NRBV first espoused by Hart (1995) debates the inevitability of business being constrained by and dependent upon nature and suggests future strategies should facilitate environmentally sustainable economic activities. The NRBV outlines three environmental capabilities that firms can develop to achieve competitive advantage each with varying degrees of technological uncertainty. Technological uncertainty refers to the level of familiarity the focal firm has with technology. Pollution prevention is considered a capability because its decentralized and tacit nature makes it difficult to observe in practice (causally ambiguous) and therefore hard to imitate (Dierickx and Cool, 1989; Hart, 1995; Lippman and Rumelt, 1982, Peteraf, 1993). Pollution prevention techniques utilize incremental changes in products and processes to reduce waste and harmful effluents. As the firm is working from an established base of knowledge and expertise low levels of technological uncertainty tend to be present. Product stewardship is a capability because it involves fluid communication across functions and organizational boundaries making it socially complex and therefore hard to imitate and substitute (Hart, 1995). . Although the entire lifecycle of a product is addressed the views, often leading to more significant changes, the views of external stakeholders are incorporated in design allowing technological uncertainty to be minimized to moderate degrees (Irwin and Hopper, 1992). Clean technologies become a strategically important capability if they are distinct to the firm and difficult for the competition to imitate (Hart, 1995, Lippman and Rumelt, 1982, Peteraf, 1993). Their radical nature mean high degrees of technological uncertainty tend to be present (Aragon-Correa & Sharma, 2003; Hart and Dowell, 2011).

Supplier Involvement in New Product Development

The SI-NPD literature has reached different and sometimes contradictory findings around the importance of involving suppliers in NPD. Several studies found early supplier involvement, often at the design stage, to be a critical factor in improved product performance (Wasti and Liker, 1997; Swink, 1999). Ragatz et al. (1997) provided evidence that early involvement reduced costs, improved quality and sped up time to market. In the mid 2000's, the SINPD literature began categorizing supplier involvement along a spectrum of engagement ranging from no involvement, to "white box", "grey box" and "black box" integration (Petersen et al., 2005). Koufteros et al. (2007) found the effects of black-box integration on product innovation to be statistically non-significant, whilst the direct effect of grey-box integration to be positive and statistically significant. This demonstrates how different degrees of supplier involvement can affect the NPD outcomes. While the aforementioned literature generally espouses the positive benefits of involvement we see negligible or negative effects when technological uncertainty is considered

During the late 1990's and 2000's several authors began to consder technological uncertainty. Petersen et al. (2003) and Ragatz et al. (2002) suggested supplier representation on NPD teams is critical, especially in situations of high technological uncertainty. In contrast, Eisenhardt and Tabrizi (1995) suggested less supplier involvement might be necessary under conditions of high technological uncertainty. Swink (1999) found supplier influence to be strongly associated with improved manufacturability but the correlation diminished in cases of high uncertainty. Finally, Primo and Amundson (2002) found existing suppliers might be less important than new suppliers in conditions of high technological uncertainty.

Research Method

This paper uses an in-depth case study of a high technology firm in the aerospace sector. The case study format was chosen because it offers in-depth data gathering and analysis. Using one case allows for the control of external effects. The aerospace industry is notoriously secret therefore it would have been very difficult to work with competitors and still have full access to deep 'dive' data. This method is supported by the literature. Voss et al. (2002) argue that case research has consistently been one of the most powerful research methods in Operations Management. Dyer and Wilkins (1991) argue single case studies enable the researcher to capture in much more detail the context within which the phenomena under study occurs. Yin (2009) also supports the use of a single case design in certain situations including uniqueness and longitudinal research, these are both important criteria relating to this study. The case study includes an upstream supplier and downstream customer termed a triadic, or three-way, design (see Choi and Wu, 2009). The Triadic case design permits an understanding of which actor is helping or hindering the embedding of product stewardship and clean technologies.

The unit of analysis is new product development project. Three projects were chosen each representing one of the three environmental strategies of the NRBV. The first project, Titanium Aluminide (TiAl), represents a pollution prevention strategy because it has been incrementally developed over the past three decades and replaces a nickel alloy which contains rare earth elements and carcinogens. The second project, carbon composites, embodies a product stewardship strategy because supplier views are incorporated in design and life cycle analysis. Carbon composites provide environmental benefits because they are a lightweight alternative to the current material removing up to eight hundred pounds of weight from the product. The third project, additive layer manufacturing (ALM), signifies a clean technology strategy because it revolutionized the manufacturing process and generates significantly less waste during the machining of components.

To improve reliability this paper uses a triangulation data collection method including semi-structured interviews, focus groups and secondary data as advocated by Yin (2009). Forty-two semi-structured interviews were conducted. A snowball sampling technique was used to select each interviewee (Taylor and Bogdan, 1998). Eight focus groups were conducted to limit confirmation bias by providing a check on the interview findings. Secondary objective data provided a further check allowing the researchers to confirm interviews and focus group findings. Data collection stopped when a point of theoretical saturation was reached, or when additional data did not provide new information or understanding (Eisenhardt, 1989). NVIVO 10 software was used to code the interview transcripts, focus group notes and secondary documentation. Using hierarchical coding, groups of similar codes were clustered together to produce more general higher order codes, or themes (King, 2004).

Findings

After rigorous analysis of the data it was apparent that two overarching themes emerged, we label these: Barriers and Enablers, because they appear to be either enhancing or restricting the firm's ability to move towards the high sustainability goals of product stewardship and/or clean technology. Under the Barriers category sit the sub-themes of: technological uncertainty, cost minimization approach, supplier relationships and intellectual property ownership. Under the Enablers category are the sub-themes of: strategic approach to sustainability, supplier collaboration and intellectual property sharing. We now discuss each of these main and sub-themes in turn.

Technological Uncertainty

Technological uncertainty emerged as the first barrier to embedding product stewardship and clean technology strategies in the NPD cycle. ALM was found to be the most adversely affected, carbon composites moderately affected and TiAl had negligibly affected. Interviewees explained the case company developed ALM in the supply chain because it had insufficient in-house knowledge or capabilities. This suggests technological uncertainty was a primary motivating factor in the outsourcing of development. The novelty of ALM to the aerospace industry also meant few suppliers had sufficient knowledge, capacity and capabilities to develop components to the high specification required (see table 1). Four interviewees explained supplier knowledge around ALM is very limited which creates uncertainty as single points of failure exist in the supply chain. High degrees of technological uncertainty also affected the extended supply chain of machines and powders. Again, the novelty of the technology to aerospace and rigorous requirements meant few raw material and machine providers could meet specifications. The competition was found to be very aggressive in purchasing promising ALM suppliers creating a competitive edge in terms of capacity whilst blocking the case company from a significant source of ALM machines.

Technological uncertainty played a more moderate role with carbon composites which were developed via a joint venture with a supplier with expertise in the material from different industries. Even though carbon composites were seen to be a strategically important technology, the case company co-developed the material to tap the supplier's experience and reduce technological uncertainty. Four interviewees felt the joint venture sped up carbon composite development in the early stages (see table 1).

Table 1: Technological uncertainty and effect on product stewardship and clean technologies

Coded Response	# of responses out of 42
Supplier maturity is very low in ALM	4
Underdeveloped supply chain for ALM machines and powders	10
Competition have bought ALM capacity and capabilities	8
Decision to Joint Venture was because supplier had more experience	2
Joint Venture helped pace of Carbon Composite development early on	4

A cost minimization approach to sustainability

A cost minimization approach to sustainability emerged as the second barrier. Twenty-eight interviewees believed cost reduction to be the primary driver of environmental performance improvements in new products (see table 2). Interviewees explained how the case company constantly strove to improve the products fuel consumption as this is the main cost incurred by customers which led to environmental benefits including lower carbon dioxide and nitric oxide emissions. Legislation was cited by twenty-five interviewees as being the secondary driver (see table 2). Interestingly both the customer and supplier saw cost reduction as the primary driver for environmental performance improvements at their company.

Table 2: Cost Minimization as a barrier to product stewardship and clean technology

Coded Response	responses out of 42
Cost reduction is the primary driver of environmental performance improvements	28
Legislation is important in improving environmental performance of products	25
Cost reduction is the primary driver (customer interviewees)	3
Cost reduction is the primary driver (supplier interviewees)	3

Supplier Relationships

The case company's approach to supplier relationships emerged as the third barrier. **S**even interviewees felt the case company had limited collaborative supplier relationships, in particular with suppliers of strategic components or technologies (see table 3). One focus group member explained the company primarily has make to print (white box) suppliers and some design-make (black box) suppliers. However, he stated there were very few instances of formalized "grey box" supplier collaborations. One interviewee explained how purchasing tends to put cost reduction pressures on its supply base regardless of the strategic importance of the component.

Nine interviewees believed suppliers were not involved early enough in the NPD process. One interviewee explains: *"I don't think we're good at leveraging our supply chain in terms of new technology, partly because we leave it too late. So the design is pretty much fixed before we start earnestly talking to suppliers"*. One focus group member felt the case company tended to give detailed instruction of product design and the supplier had to adhere to this specification, however little help was given if the supplier couldn't meet these stringent guidelines. Finally, one interviewee felt the case company was reluctant to commit to a longer term spend with suppliers (see table 3).

Table 3: Supplier relationships as a barrier

Coded Response	responses out of 42
The case company needs more collaborative relationships with suppliers	7
Purchasing too focused on finding lowest cost supplier	4
Cost reduction pressures on suppliers inhibits ability to invest in R&D	2
Not enough resources for developing capabilities of strategic suppliers	7
Suppliers not involved early enough in new technology development	9

Intellectual Property Protection

The ownership of intellectual property emerged as the fourth barrier. Seventeen interviewees highlighted IP ownership as creating issues in supplier relationship and the longer term development of the technology (see table 4). Seven interviewees felt tension arose because the case company wants to own all foreground IP, or all the newly generated IP between the two parties. In fact, one interviewee explained that suppliers were not involved early in the NPD process because of the issue of IP ownership.

Table 4: Intellectual property ownership as a barrier

Coded Response	responses out of 42
Ownership of IP creates issues in supplier relationships	17
Case company tries to own foreground IP in new projects with supplier	7
Supplier unwilling to sign agreement where case company owns foreground IP	1

Strategic Approach to Sustainability

The first enabler of embedding product stewardship and clean technology strategies is termed 'strategic approach to sustainability'. This theme includes maintaining top management support and developing a sustainability value proposition for customers. Ten interviewees said some customers were beginning to compete based on a sustainability platform (see table 5 below). This gives the case company an opportunity to move past cost reduction towards developing a sustainability value proposition to win customer orders. Seventeen interviewees expressed concern that the case company's senior management team did not maintain focus on strategic technologies, materials or

components in the early stages of development. This finding was found to be true of all three new product development projects. Lack of focus meant these technologies were stopped and re-started delaying overall development times. In realization of this fact, the senior team implemented what it calls its "top eleven" technologies which are deemed critical in achieving competitive advantage. Several interviewees felt once ALM, carbon composites and TiAl were nominated as top 11 technologies their rate of development increased dramatically.

Table 5: Strategic Approach to Sustainability as an enabler

Coded Response	Responses out of 42
The customer's sustainability agenda now drives environmental performance	10
Customer requirements now drive strategy process	9
The case company need to maintain strategic focus on key technologies	17
Increased top level support has sped up development of ALM & CarbComp	3

Supplier Collaboration

Improving collaboration with suppliers was seen as the second enabler. A Supply Chain Collaboration Manager has recently been appointed to improve relationships with strategic suppliers. One interviewee felt supplier collaboration could be improved through investing in the capabilities of suppliers of strategically important technologies such as ALM. Two interviewees stressed the need to create a longer term spend suppliers can rely on. A supplier interviewee explained that with longer term guarantees the supplier could secure financial backing to invest in developing their technological capabilities. Two supplier interviewees stressed collaboration should start during design and their company is willing to provide training courses to engineers and designers.

Table 6: Collaborative supplier relationships as an enabler

Coded Response	Responses out of 42
Case company now recognizes the importance of supplier collaboration	5
The case company should create spend for strategically important tech	1
If supplier had business guarantees could increase capacity (supplier)	1
Supplier now assists case company in optimizing design (supplier)	1
By consulting on design supplier can challenge ways of thinking (supplier)	3

Intellectual Property Sharing

IP sharing emerged as the fourth enabler. Thirteen interviewees stressed the need for an IP ownership strategy prior to engaging suppliers (see table 7.0). One interviewee suggests the use of supplier workshops during the early product development stages. Three interviewees felt if a collaborative relationship were in place then IP could be shared. One supplier interviewee suggested having licensing mechanisms within the supplier contract so the supplier could benefit if IP is used elsewhere.

Table 7: IP sharing as an enabler

Coded Response	responses out of 42
Need clear IP ownership strategy before engaging suppliers	13
If collaborative relationship in place IP can be shared with suppliers	3
Case company should only protect IP that is strategically important	2
Need licensing mechanism so supplier can see future benefit (supplier interviewee)	1

Discussion

Four barriers to the involvement of suppliers in product stewardship and clean technology strategies emerged; technological uncertainty, a cost minimization approach to sustainability, supplier relationships and intellectual property. The findings suggest when technological uncertainty is low, as with TiAl, technology is developed in-house with informal supplier input (white-box involvement). When moderate degrees are present, as with carbon composites, the case company formed a collaborative joint venture to benefit from the supplier's knowledge and expertise (grey box involvement). When technological uncertainty is high, the case company relied on small suppliers with existing ALM capabilities (black box involvement). The second barrier is a cost minimization approach to sustainability. All three companies saw sustainability as primarily a cost and compliance exercise. Some interviewees felt some customers were beginning to compete on a sustainability platform giving the case company an opportunity to develop a sustainable value proposition to win customer orders. The "top 11" programme shows that with sufficient senior support product stewardship and clean technologies can be embedded quicker in NPD. The third barrier is the nature of supplier relationships. Several interviewees called for more collaboration and involvement before the design specification was set. The final barrier is intellectual property ownership. Several interviewees felt if collaborative supplier relationships were in place then IP could be shared.

A decision matrix is presented in figure 1 to help managers decide which type of supplier relationship to pursue when embarking on pollution prevention, product stewardship or clean technology strategies. The matrix suggests different types of supplier relationships depending on the degree of technological uncertainty and the supplier's environmental design and development capabilities. If the buyer has limited in-house knowledge and the supplier is able to demonstrate significant environmental design and development capabilities then a "black box" supplier relationship should be pursued. If the buyer has moderate levels of knowledge and the supplier has good environmental credentials then a grey box relationship is recommended. If the buyer has sufficient in-house knowledge and the supplier limited design for environment capabilities white box involvement is recommended.

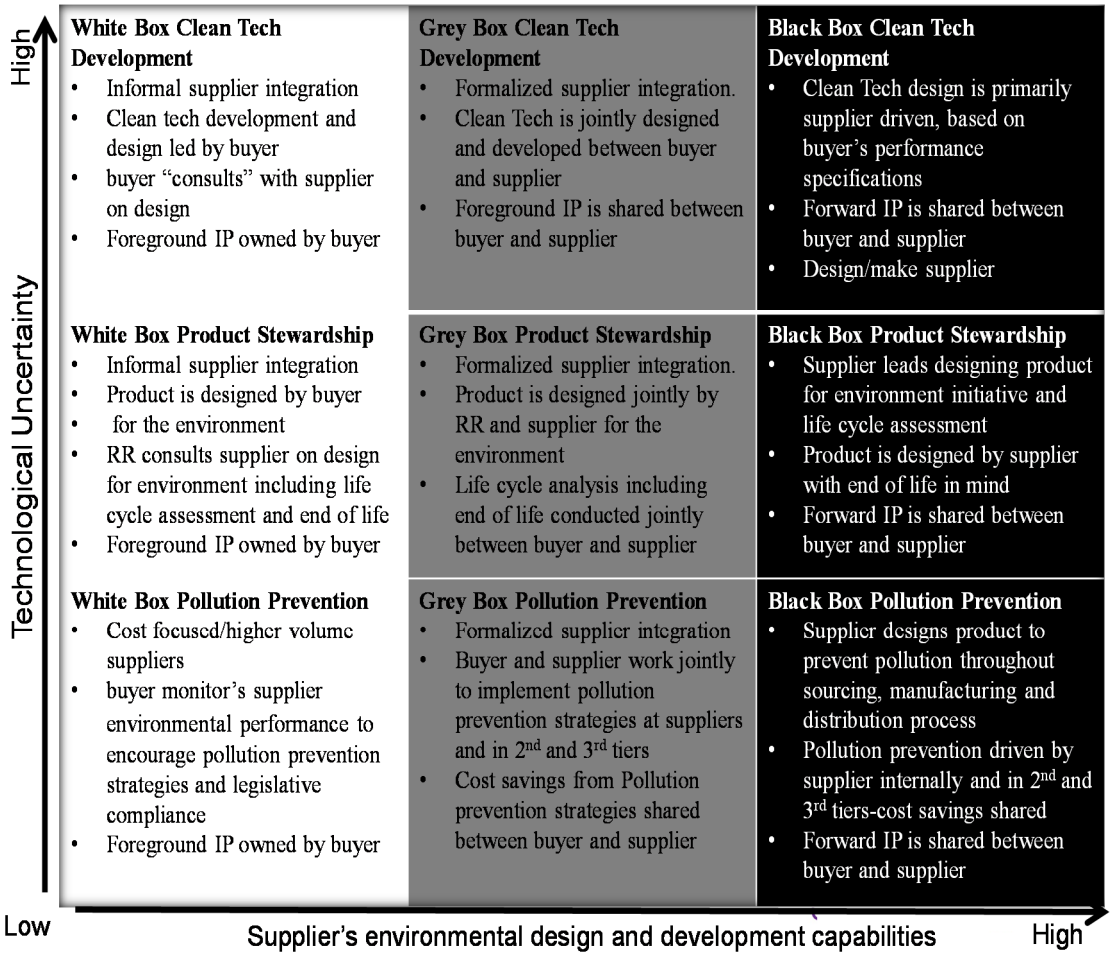

Figure 1: Decision Matrix

Conclusion

Theoretically, the paper explores the role that technological uncertainty plays in product stewardship and clean technology strategies. The findings suggest that companies will outsource design and development of new technologies when technological uncertainty is moderate to high. Specifically, when a company recognizes it lacks the necessary design and development capabilities in-house it will engage with suppliers to fill this gap in knowledge and experience. Supplier involvement then seems to be a strategy to mitigate technological uncertainty when embedding product stewardship and clean technology strategies in the NPD cycle. Furthermore, the paper makes a contribution to the SINPD literature by isolating potential environmental benefits of involving suppliers in embedding product stewardship and clean technology strategies during new product development efforts.

Practically, the paper advances a decision matrix to assist managers in determining the most appropriate type of supplier relationship to pursue when utilizing product stewardship and clean technology strategies. The paper also highlights key barriers and enablers of supplier involvement in product stewardship and clean technology strategies allowing managers to isolate these factors in their own supply chain.

The research benefited from, but is also limited by, the single case study method. This method provided the depth of information needed to study this relatively new and unexplored area but only gathered the opinions of the case company employees, its supplier and customers. Further barriers or enablers are likely to emerge if other companies or industries are studied. Future researchers could investigate if the same factors emerge when studying high technology firms in other industries. Other research

avenues include looking at other triadic configurations, such as supplier-supplier-buyer triads and their influence on product stewardship and clean technology strategies.

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